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Difficult birth is the main contributor to birthrelated fracture, and accidents to other neonatal fractures

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Abstract

Aim: Specific birthrelated fractures have been studied; underestimates might be a problem. We aimed to assess all fractures diagnosed as birthrelated as well as other neonatal fractures.

Methods: A population-based study on all infants born in Sweden 1997-2014; data was retrieved from the Swedish Health Registers (10th version of International Classification of Diseases. Outcome measures were birthrelated fractures (ICD-10 P-codes) and other neonatal fractures (ICD-10 S-codes).

Results: The overall fracture incidence was 2.9 per 1,000 live birth (N=5,336); 92.6% had P-codes and 7.4% (S-codes). Some birthrelated fractures were diagnosed beyond the neonatal period. Other neonatal fractures could have been birthrelated. Clavicle fracture, (88.8%) was associated with adverse maternal- and infant anthropometrics and birth complications. The few neonates with rib fractures all had concomitant clavicle fracture. For skull fractures, a minor part was birthrelated, most were associated with accidents. Half of the long bone fractures were associated with accidents. Birthrelated femur fractures were associated with bone fragility risk factors. Five infants with abuse diagnoses had fractures: skull (4), long bone (2), and rib (1).

Conclusion: Birthrelated and other neonatal fractures are rarely diagnosed. Difficult birth is the main contributor to birthrelated fracture, and accidents to other neonatal fractures.

Keywords: Abuse, Accidents, Birth Injuries, Fractures, Newborn Infants

Key Notes:

- Few studies have addressed birthrelated and other neonatal fractures by cause and age at diagnosis.
- Difficult birth is the main contributor, clavicle fractures were the most prevalent fracture with a few concomitant with rib fractures, while most skull fractures were caused by fall accidents.
- Birthrelated and other neonatal fractures are rarely diagnosed, diagnosis can be delayed, and underestimates cannot be excluded.

INTRODUCTION

Fractures diagnosed among neonates are mainly birthrelated. Other fractures diagnosed among neonates are mainly accidental. We set out to explore in a national register the current rate of birthrelated and other fractures in the neonatal period, and their association with perinatal risk factors.

Clavicle fractures are by far the predominant birthrelated fractures, occurring as a result of the fetal anterior shoulder being compressed against the maternal symphysis pubis or when manoeuvers to diminish the chest circumference in shoulder dystocia is performed. Hospital studies report a clavicular fracture incidence of 0.2% - 2.9%, diagnosed by clinical routine examination or due to symptoms, or incidentally found in postnatal x-rays or after discharge. Maternal obesity, short stature, high birth weight and shoulder dystocia are well-known risk factors (1). Clavicle fracture has further been used as an obstetric patient safety indicator (2).

Rib fractures, also multiple, are rarely reported in association with birth, only as case reports, but may have the same origin as clavicle fractures, caused by the shoulder compression forces to the chest (3, 4), or in association with bone fragility (5). International Classification of Diseases – 10th version (ICD-10) does not provide a special code for birth-related rib fractures.

Humerus fractures may result as a direct trauma in delivering arm in case of shoulder dystocia. However, such fractures are rarely reported. Basha et al reported only two cases in a total of nearly 35,000 births, in conjunction with spontaneous vaginal birth and Caesarean section with cephalic presentation (6).

Femur fractures were previously associated with difficult vaginal breech delivery, usually an error of art when applying too much power or in the wrong direction to the bone. Today, such fractures have also been reported in Caesarean breech delivery, in other malpositions, due to power during the extraction, or in association with preterm or twin deliveries (6, 7). Femur fractures are reported to have an incidence of 0.13 - 0.17 per 1,000 live births (6, 7). Classical metaphyseal lesions, considered as highly specific for abuse (8), have been reported in association with uncomplicated caesarean delivery preceded by external version and in a difficult caesarean footling breech extraction (9). Orthopaedic surgeons do alert clinicians to be aware of possible birthrelated transphyseal fractures of lower limb and that appropriate treatment might prevent sequelae (10).

Skull fractures are rare in modern obstetrics (0.001 – 0.01%), although they may be underestimated (11), as an incidence of 2.9% has also been reported (12). Considering the fact that the head in the majority of infants is the largest part of the body to pass the birth canal, and that it undergoes an almost extreme moulding during this passage (13), it is conceivable that some skull fractures may remain undetected. Greenstick skull fractures are stated to be the most common, followed by depressed and linear type (11). Birthrelated skull fractures are associated with assisted vaginal delivery or Caesarean after failed assisted vaginal delivery (14).

Not birthrelated fractures observed later during the neonatal period might be accidental and caused by short falls. Monson et al (2008) reported 14 neonatal in-hospital falls (0.16 per 1,000), only one resulted in a skull fracture (15). Nine cases of skull fractures have been reported after falling from hospital bed or from parent´s arms (14).

Fractures among neonates may be diagnosed as non-accidental as long bone fracture and rib fracture are considered to have high association with maltreatment diagnoses (16).

Present knowledge about birth related fractures is mainly derived from single hospital studies or case reports that address specific types of fracture. Wide differences in reported incidences of birthrelated fractures might also indicate that underestimates are a problem. To our knowledge, no national study has been conducted that includes all fractures diagnosed as birthrelated and other fractures diagnosed during the neonatal period. The aim of this study was to describe fractures diagnosed as birthrelated by type, age at diagnosis and associated maternal, birth and newborn infants characteristics, and other fractures occurring during the neonatal period.

MATERIAL AND METHODS

Design

This nationwide population-based register study comprised 1,855,267 infants born in Sweden between January 1997 and December 2014. We followed the infants until one year of age and their mothers by using data from the National Patient Register (NPR) and the Swedish Medical Birth Register (SMBR) maintained by the Swedish National Board of Health and Welfare (17). During the study period, the National Patient Register used diagnosis codes from ICD-10 (Swedish version).

Cases

Out of all children born during the 18-years period, we selected all infants with a fracture diagnosis according to birthrelated fractures (ICD-10 P-codes=Birth Injury to skeleton) or other neonatal fractures (ICD-10 S-codes) in early (1 – 7 days) or late neonatal period (8 – 28 days) in ICD-10 (Table 1).

We categorized a number of exposures. The maternal exposures included: 1) Age: 34 or below, 35 or above, 2) Parity: one, two or more, 3) Height: <160cm, 160.0-160.9cm, and 170cm or above, 4) Body mass index (BMI) at the start of pregnancy: normal (18.5–24.9), overweight (25–29.9) and obese (30+). Delivery factors were: 5) Dystocic labour, 6) Presentation: occiput anterior, occiput posterior brow, breech, others, 7) Mode of delivery: spontaneous vaginal delivery - SVD, vacuum, forceps, planned Caesarean or emergency Caesarean, 8) shoulder dystocia). The infant factors were 9) Sex, 10) Single or multiple birth, 11) Term or preterm birth:<32 and 32-36 gestational weeks, 12) Birth weight in gram: <2,500, 2,500-3,499, 3,500-3,999, 4,000-4,499, 4,500 or more, 13) Head circumference in centimetre: ≤35, 36-37, 38 or more, 14), Small-for-gestational age (SGA): (<2.5th or <10th percentiles.

Controls

Infants that were entered in the National Patient Register (NPR), but without birthrelated or other fractures during the neonatal period served as controls as previously described (18).

Statistical analyses

Birthrelated fractures were described by type (clavicle – P13.4, skull – P13.0, other skull – P13.1, femur – P13.2, other long bone – P13.3 and others and unspecified – P13.8-9), day of diagnosis (median and minimum - maximum), and by interval (1-6/8-28/29-58, 59-89/90+), and the incidence proportion per 1,000 infants live born.

Other neonatal fractures, not diagnosed as birthrelated, were described by numbers, age at diagnosis categorized in early and late neonatal periods, and reported fall or transport accident.

The Fisher's exact test or Mantel-Haenscels chi square were applied to assess differences between the infants with fractures (clavicle – P13.4, skull – P13.0 & other skull – P13.1, femur – P13.2, other long bone – P13.3) and the control population.

Multiple logistic regression was performed to evaluate odds ratio with 95% confidence intervals of vaginally delivered infants with a clavicle fracture with the following categorized covariates: primiparity, maternal height (<160 cm, 160.0-160.9 cm) and BMI (25–29.9 and 30+), dystocic labor, shoulder dystocia, mode of delivery (vacuum), child´s sex, birth weight in gram (3,500-3,999, 4,000-4,499, 4,500 or more), and head circumference in centimetre (36-37, 38 or more). Adjusted odds ratios (aOR) were analysed; in model 1 maternal and child´s anthropometrics were entered, in model 2 birth complications were added. For the statistical analysis, we used the statistical software package SPSS, version 25.0 (IBM Corp, New York, USA) and OpenEpi (19)

The study was approved by the Regional Ethical Committee in Uppsala (2014-11-19, No. 383). This committee approved a waiver of informed consent, considering that the research database contained only coded data. For cases with abuse diagnoses, we had ethical permission to review clinical records (2015-11-18 No 383/2).

RESULTS

In all, we found 5,336 fractures, 2.9 per 1,000 live births, diagnosed as birth related fractures (ICD-10 P-codes) (92.6%) and other neonatal fractures (ICD-10 S-codes) (7.4%). Eleven children died during their first year. None of those children had a fracture diagnosis stated as a main or contributory death cause whereas six children had any neonatal diagnoses. A total of 4,943 infants had a birthrelated fracture. Clavicle fractures were by far the most frequent, found in 95.5% of the infants with fractures (n=4,736), followed by other long bone fractures in 2.9% (n=144), skull fractures in 0.81% (n=40), femur fractures in 0.79% (n=39), and other unspecified fractures in 0.71% (n=35). The incidences per 1,000 live births were clavicle 0.26, other long bone 0.08, skull/other skull 0.02, and femur 0.02 (Table 2).

A total of 515 fractures were found ascribed to other neonatal fractures: long bone (n=231), skull (n=139), clavicle (n=133) and rib (n=12) (Table 3).

The proportion of male sex for the types of birthrelated fractures were clavicle 59.1%, other long bone 65.3%, skull 67.5% and femur 61.5%. For other neonatal fractures the proportions of male sex were clavicle 51.1%, long bone 63.6%, skull 52.5%, rib 58.3%.

The great majority of the birthrelated fractures was diagnosed at first day of life (92.4 %), or within the early neonatal period (94.1 %). During the late neonatal period, only 4.7% of the clavicle fractures were diagnosed, as well as three femur fractures, 26 other long bone fractures, and 14 other or unspecified fractures. Few were diagnosed beyond the neonatal period: 1.1% of the clavicle fractures, eight skull fractures, and nine other long bone fractures (Table 2).

Other neonatal fractures (ICD-10 S-codes), 48.2% were diagnosed in the early and 51.8% in the late neonatal period (Table 3).

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Maternal, birth and infant characteristics

Table 4 shows information of birthrelated fractures by type and by maternal, birth and child characteristics. Maternal short stature and overweight/obesity were associated with clavicle fracture and other long bone fractures.

Dystocic labor was associated with all fracture types, except other skull fractures.

Shoulder dystocia occurred among 4.3% of those with clavicle fracture, and in one-third of those with other long bone fractures, three cases had both clavicle fracture and other long bone fracture.

Assisted vaginal delivery by vacuum extraction was associated with clavicle fracture (21.8%), skull fracture (45.8%) and other long bone fracture (26.4%).

Breech presentation was associated with femur fractures (69.2%); caesarean delivery was performed in more than two-thirds of those having a breech presentation. Adverse mode of presentation at birth was common for all fracture types, especially for femur fracture, of which two-thirds had a breech presentation. Those with femur fracture were more often twins, had low birth weight and were small-for-gestational age. Moderate preterm born had more skull fractures, femur fractures and other long bone fractures. A birth weight above 3,500g was associated with clavicle fractures, a birth weight above 4,000g also with other long bone fractures.

Odds for clavicle fractures

Table 5 shows risk factors for clavicle fracture among vaginally delivered infants. Odds ratios for clavicle fracture, when adjusted for birth complications, maternal and infant anthropometrics, and infant sex (Model 2), were maternal short stature: aOR 2.02 (95%CI 1.79-2.30), maternal overweight: aOR 1.26 (95%CI 1.16-1.37), maternal obesity: aOR 1.48 (95%CI 1.34-1.65), shoulder dystocia: aOR 4.84 (95%CI 3.70-6.32), vacuum delivery: aOR 2.52 (95%CI 1.61-3.92), and birth weight > 4,500 g: aOR 13.19 (95%CI 11.3-

15.4). For Model 1, which included only maternal and infant anthropometry, the adjusted odds ratios were rather similar.

Other neonatal fractures and accidents

Table 3 shows the distribution of other neonatal fractures attributed to fall accidents (42.1%) and transport accidents (7.2%). A total of 87.6% of the skull fractures were diagnosed as accidental; fall accidents in four-fifths and transport accidents in one-fifth of the cases. A total of 68.3% of long bone fractures were diagnosed as accidental; fall accidents in four-fifths and transport accidents in one-fifth of the cases. Clavicle fractures diagnosed during early neonatal period had less association with accidents, but had maternal, birth and infant characteristics indicating that they were caused by a birth trauma.

Rib fractures

Some rib fractures (n=10) were diagnosed in early neonatal period, none of which had had cardiopulmonary resuscitation; all of them had also a clavicle fracture; four of the ten had a dystocic labor, four had vacuum delivery, one was delivered by emergency caesarean, five had a birth weight > 4,000g, one also had a long bone fracture, and one had a skull fracture (Table 3).

Abuse diagnoses

Five infants had an abuse diagnosis at age 1, 16, 20, 22 and 26 days. All were girls with spontaneous births, and four were single and term born. The case diagnosed at day 1 were born twin at gestational age 30 weeks had subdural haemorrhage, skull fracture and rib fractures. No clinical record was found. The case diagnosed at day 16 had a complicated birth with secondary arrest and fundal pressure was exerted. At time of diagnosis the infant had subdural haemorrhage, retinal haemorrhage, humerus fracture, rib fracture, and classical metaphyseal lesions. Later investigation showed vitamin D deficiency at birth. The case diagnosed at day 20 had birth weight of 3,980g, At time of diagnosis an abdominal x-ray because of vomiting revealed healing rib fractures, and further radiology showed skull fracture. The case diagnosed at day 22 had a short fall of about 1 m, skull fracture, and subdural haemorrhage, which was later classified at as a fall accident not abuse. The case diagnosed at day 26 had a birth weight of 2,655g, small-for-gestational age (<10%), and long bone fracture.

DISCUSSION

To our knowledge, this is the first population register-based study assessing birthrelated fractures (ICD-10 P-codes) and other neonatal fractures (ICD10, P-codes), respectively. In all, we found 5,336 fractures, 2.9 per 1,000 live births, diagnosed as birthrelated (92.6%) and other neonatal fractures (7.4%). Clavicle fracture was by far the most common birthrelated fracture and was associated with short maternal height, maternal overweight or obesity, shoulder dystocia, vacuum delivery and increasing birth weight. Out of all skull fractures, only a minor part was birth related, half of those were related to dystocic labour or use of vacuum. Most skull fractures were neonatal and associated with fall accidents or transport accidents.

The overrepresentation of adverse maternal or fetal anthropometrics and birth complications such as dystocic labor, shoulder dystocia and vacuum delivery do support that infants with birthrelated fractures are exposed to excessive forces during birth. Expulsive forces on the fetal head are reported to be 16 N (Newton units) at rest, 54 N during uterine contraction, and 120 N during pushing (20). The traction force during vacuum extraction is on average 225 N (21).

Out of all long bone fractures, half occurred during the neonatal period and two thirds was associated with accidents. Birthrelated femur fractures were associated with breech delivery, whether Caesarean or not, multiple births, preterm and small-for-gestational age. All rib fractures diagnosed in the early neonatal period also had the typical birthrelated clavicle fractures, suggesting that the forces during delivery may cause rib fractures too.

Our results show that the diagnosis of birthrelated fractures might be delayed; although the absolute majority was diagnosed in the early neonatal period, a small portion was diagnosed in the late neonatal period, and some even later in infancy. One less plausible possibility is that fractures during late infancy have been diagnosed incorrectly as birthrelated; however, this possibility cannot be ascertained by our study design.

Delayed diagnosis, after discharge, has previously been reported for clavicle fractures in 13 – 39% (1), and mean duration to diagnosis of femur fractures has been reported to be 6.3 days (7); in one case the diagnosis was made on day 9 (22), indicating that non-dislocated birth-related fractures are not easily diagnosed (1, 7, 22). Clavicle fractures diagnosed later during the neonatal period had similar risk factors as the birth related clavicle fractures. This might indicate that they possibly could have been birthrelated and that fractures diagnosed during infancy without a recent trauma exposure might be birthrelated. In the routine examination of newborn infants, clavicle fractures are especially looked for, whereas other fractures might be overlooked if there are no symptoms. However, if no crepitation or callus formation is found at the examination, there is still a risk for a fracture to pass unnoticed.

A linear skull fracture or a fracture without loose fragments or indentations may be clinically silent and therefore not discovered, unless specifically looked for because of suspected accidental or intentional head injury, as suggested by Nachtergaele et al, who on the basis of literature estimated that between 2.9 and 10 % of all new-borns had a cranial fracture (12). This may explain why skull fractures appear to occur infrequently. The recent publication by Ami et al gives an indication of the strong forces acting on the head during birth; maybe clinically silent skull fractures are much more common after birth than reflected in the data presented here. As the head in most infants is the largest part of the body to pass the birth canal, and as it undergoes an almost extreme moulding during this passage (13), one would expect these forces to cause skull fractures to a larger extent than revealed in the present study.

To our knowledge, the present study is the largest study addressing birthrelated fractures; it showed a lower incidence of clavicle fracture, 0.26%, than previously reported (1, 2, 23-25), and a lower incidence of femur fracture, 0.01%, than reported before (6, 7). Estimates of the incidence of birthrelated fractures will never be accurate; in one study half of the clavicle fractures were for instance found incidentally by x-ray (1). However, our results do confirm present knowledge, that exceedingly high power exerted on the fetus might fracture the skeleton due to adverse maternal and fetal anthropometrics and delivery complications, especially for clavicle fractures (1, 23-25) and skull fractures (14). Still, fractures do occur without any perceived complication or risk factors, only 4.3% of the clavicle fractures were associated with shoulder dystocia, and half of them occurred among newborn infants with a birth weight below 4,000g.

All 10 rib fractures diagnosed in the early neonatal period had shoulder dystocia, never has so many cases been reported before (3, 4). The interpretation is that the same power that cause clavicle fracture might also cause rib fractures. Most probably, rib fractures could be underestimated, as they could be clinically silent in newborn infants, and overlooked on chest x-ray before callus formation. Neither there is special P-code for rib fracture and those might be overlooked in clinical and register studies.

Bone fragility conditions seemed to play a minor role in birthrelated fractures. Only femur fractures were associated with metabolic bone disease risk factors such as multiple birth, preterm birth and small-for-gestation age (5). Even though 28 of all infants found with femur fracture were delivered by Caesarean section, the cause of femur fracture could as well have been difficult extraction. Whether there were cases of transphyseal fractures (10) among our femur or other long bone fractures could not be ascertained by this study design, as ICD-10 has no specific code indicating such fractures.

Slight or moderate trauma level fall accidents were associated with most skull and long bone fractures in neonates, as previously shown for the rest of the first year in life (5). Our results show that a diagnosis of skull fracture is more commonly associated with neonatal accidents than being birth related. Only small case series have previously reported this among neonates (14, 15, 26).

There were five cases with abuse diagnoses, with any of the following: skull, clavicle, long bone, or rib fractures, retinal haemorrhage and subdural haemorrhage. The precision of the abuse diagnosis of these cases was hampered by incomplete access to records, but four of these cases could be classified within the shaken baby syndrome/abusive head trauma concept (3, 8, 16). However, there is low evidence that subdural haemorrhage or retinal haemorrhage can be associated with shaking (27) and the evidence that long bone fracture and rib fracture have high specificity for abuse (16) appears to be biased by circular reasoning (28). Hence, false positives among the cases with abuse diagnosis cannot be excluded.

Strengths and limitations of the study

The strength of this study was the population design with national coverage over a long period, the prospective data collection, uniform use of the ICD10 and probably a rather high reliability of the diagnostic processes. The dataset, including the population-based controls, implied population representativeness. Moreover, the Swedish health registers are considered to have high validity (29, 30), however fracture diagnoses has not been specifically evaluated. Underestimates of birth related fractures could not be ascertained in our study, especially for birth related clavicle fracture that mostly is clinically diagnosed. A Finnish register study, with similar design and setting, reported a 4-fold higher clavicle incidence than our results (2), thus our incidence of clavicle fracture is likely to have been an underestimate. This might be the case as well had been the case for asymptomatic skull fractures and rib fractures. A major limitation was that we did not had access to the clinical records for further assessment of events preceding the diagnosis of a fracture, such as obstetrical manoeuvers during extraction of the infant, regardless of mode of delivery. Neither could we differentiate between occult fractures found incidentally by x-ray, and those that were symptomatic.

CONCLUSION

Birthrelated fractures and other neonatal fractures were rare and, diagnosis in some cases delayed. Underestimates cannot be excluded. Adverse maternal- and infant anthropometrics and delivery complications were the main risk factors for birthrelated fractures. Fall and transport accidents were the main contributors to other neonatal fractures, especially skull and long bone fractures.

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Conflicts of interest

The authors have no conflicts of interest to declare.

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Table 1. Definitions of fractures, accidents and others. Swedish version of the International statistical Classification of Diseases (ICD10).

Category	Diagnosis	ICD 10 codes
Birth injury to skeleton		
	Fracture of skull due to birth injury	P13.0
	Other birth injuries to skull	P13.1
	Birth injury to femur	P13.2
	Birth injury to other long bones	P13.3
	Fracture of clavicle due to birth injury	P13.4
	Birth injuries to other parts of skeleton	P13.8
	Birth injury to skeleton, unspecified	P13.9
Fractures		
	Skull fracture	S02.0, S02.1, S02.8, S02.9
	Clavicle	S42.0
	Rib fracture	S22.3, S 22.4
	Long bone fracture	S42.2, S42.3, S42,4, S42.7, S42.8, S52, , S72, S82, T10, T12
Accidental injury		
	Transport accident	V01-99
	Fall accidents	W00-19
Others		
	Dystocic labor	O62-O67
	Infant abuse diagnosis (observation for suspected abuse, battered baby syndrome, maltreatment syndrome)	Z03.8K, Y07, T74.1, Y06.

Table 2. Birthrelated fracture (only P13 ICD10-codes) among infants born in Sweden 1997 to 2014 by median (minimum-maximum), period of diagnosis, and incidence per 100,000 births. Source: The Swedish Birth Register (SBMR) and the National Patient Register (NPR).

	Birthrelated fractures					
	Clavicle (P13.4) (n=4,736) [1]	Skull (P13.0) (n=24)	Other skull (P13.1) (n=16)	Femur (P13.2) (n=39)	Other long bones (P13.3) (n=144)	Others and unspecified (P13.8, P13.9) (n=35)
Median days of diagnosis (min-max)	1 (1-344)	1 (1-52)	17 (1-206)	1 (1-56)	1 (1-358)	4 (1-182)
Diagnosis at age:						
1	4,400	20	7	28	96	16
2-6	61	2	2	6	13	2
7-28	222	1	2	3	26	14
28-58	45	1	1	2	6	2
59-89	4	0	6	0	3	1
90+	4	0	0	0	0	0
Incidence[2] (per 1,000)	0.26	0.01	0.01	0.02	0.08	0.02

[1]2 cases of maltreatment diagnosis (days 181 & 238) with no diagnoses of subdural haemorrhage, retinal haemorrhage, rib fracture or long bone fracture.
[2]N=1,855,267

Table 3. Neonatal fractures (only S codes for fractures, not cases with P codes (birthrelated fractures) among infants born in Sweden 1997 to 2014 by age 1-7 and 8-28 days, fall and transport accidents. Swedish version of the International statistical Classification of Diseases (ICD10). Source: The Swedish Birth Register (SBMR) and the National Patient Register (NPR).

Fracture types	Age at diagnosis (days)						
	1-28	1-7 days			8-28 days		
	All	All	Fall accidents	Transport accidents	All	Fall accidents	Transport accidents
	n	n	n (%)	n (%)		n (%)	n (%)
Skull	139	52	29[1] (55.8)	14 (26.9)	87	80[2] (90.1)	4 (4.6)
Clavicle	133	44[3]	5[4] (11.3)	3 (6.8)	89[5]	25[6] (28.1)	1 (1.1)
Rib	12	10[7]	0	1 (10)	2[8]	1[9]	0
Long bone	231	142	42[10] (28.2)	11 (7.7)	89[11]	41[12] (46.1)	3(3.4)
All	515	248	74 (29.8)	29 (11.7)	267	145 (54.3)	8 (3.0)

[1]Fall being carried: 5; Fall from furniture: 2; Unspecified fall: 3; Fall from bed: 17.

[2]Fall from furniture: 20; Fall being carried: 31; Unspecified fall: 13; Fall same level: 3; Fall from bed: 8; Fall from stair or steps: 5.

[3]Maternal BMI ≥25: 21; Maternal height <160 cm: 2; Birth weight ≥4,000 gr: 23; Vacuum:7; Shoulder dystocia 2.

[4]Unspecified fall: 4; Fall being carried: 1.

[5] Maternal BMI ≥25: 33; Maternal height <160 cm:19; Birth weight ≥4,000 gr: 23;,Vacuum:9; Shoulder dystocia 5.

[6] Unspecified fall: 21; Fall from bed: 1; Fall being carried: 1; Fall same level: 1; Fall from furniture: 1.

[7]Preterm:2; Birth weight <2,500: 3, Birth weight <2,500: 3, Birth weight ≥4000 gr: 5, ≥4000 gr: 5; Shoulder dystocia: 1; clavicle fracture:10

[8]Preterm: 0; Birth weight <2,500: 0; Birth weight Birth weight <2,500: 3, Birth weight ≥4000 gr: 5, ≥4000 gr: 0; Shoulder dystocia: 1; Clavicle fracture: 2.

[9]Fall being carried: 1 and abuse diagnosis: 1 (Girl, twin, born gestational week 30, birth weight 1,550 gr, small-for-gestational age, subdural haemorrhage, retinal haemorrhage).

[10]Fall from stairs or steps: 1; Fall from bed: 1; Fall same level: 3; Fall being carried: 1; Unspecified fall: 34, Fall from furniture: 2.

[11]Abuse diagnosis: 3 (One boy, two girls, single born, term born, birth weights 2,655, 2,930, 3,810 gr, 1 had retinal haemorrhage, none subdural haemorrhage).

[12]Fall from stair or steps: 1; Fall same level: 3; Unspecified fall: 36, 1 had abuse diagnosis; Fall being carried: 1.

Table 4. Birthrelated fracture (only P13 ICD10-codes) among children born in Sweden 1997 to 2014 by type, maternal and birth characteristics. Source: The Swedish Birth Register (SBMR) and the National Patient Register (NPR). Exposure by type compared the population, p-value (2-tail) Fisher exact test or Mantel-Haenscel chi square (Clavicle).

		Population	**Birthrelated fractures** Clavicle (P13.4) (N=4,736)	Skull (P13.0) & Other Skull (P13.1) (N=40)	Femur (P13.2) (N=39)	Other long bones (P13.3) (N=144)
		N (%)	n (%) $^{p\text{-value}}$	n (%) $^{p\text{-value}}$	n (%) $^{p\text{-value}}$	n (%) $^{p\text{-value}}$
Mother						
Age	<35	715,039 (79.1)	3,774 (79.1) $^{0.317}$	31(77.5) $^{0.925}$	36 (92.3) $^{0.050}$	106 (73.6) $^{0.134}$
	35+	188,790 (20.9)	961 (20.3)	9 (22.5)	3 (7.7)	38 (26.4)
Parity	I	397,667 (44.0)	1,907 (40.3) $^{<0.001}$	19 (47.5) $^{0.770}$	24 (61.5) $^{0.042}$	49 (34.0) $^{0.019}$
	II+	506,162 (56.0)	2,828 (59.7)	21 (52.5)	15 (38.5)	95 (66.0)
Height	<160	114,647 (13.4)	650 (14.3) $^{<0.001}$	7 (18.9) $^{0.630}$	4 (11.8) $^{0.600}$	34 (24.3) $^{0.001}$
	160-169.9	462,011(54.5)	2,607 (57.5) $^{<0.001}$	18 (48.7) $^{0.893}$	15 (44.1) $^{0.213}$	67 (47.8) $^{>0.999}$
	170+	274,640 (32.1)[1]	1,270 (28.1)	12 (32.4)	15 (44.1)	39 (27.9)
BMI[2]	18.5-24.9	496,287 (62.2)[1]	2,206 (52.2)	19 (53)	16 (34.4)	65 (49.2)
	25-29.9	203,741 (25.5)	1,269 (30.0) $^{<0.001}$	11 (31) $^{0.469}$	11 (34.4) $^{0.265}$	38 (28.8) $^{0.107}$
	30+	97,915 (12.3)	753 (17.8) $^{<0.001}$	6 (16) $^{0.440}$	5 (15.6) $^{0.514}$	29 (22.0) $^{<0.001}$
Birth						
Dystocic labor		134,365 (14.9)	1,071 (22.6) $^{<0.001}$	15 (37.5) $^{<0.001}$	12 (30.8) $^{0.018}$	78 (54.2) $^{<0.001}$

Mode of presentation	Occiput anterior	783,743 (89.5)[1]	4,496 (97.9)	32 (82) [0.196]	9 (23.1)	108 (79.4)
	Occiput posterior/ brow	37,594 (4.3)	39 (0.8) [<0.001]	1 (2.6)	2 (5.1)[0.175]	8 (5.8)[0.326]
	Breech	34,030 (3.9)	33 (0.7) [<0.001]	3 (7.7)	27 (69.2)[<0.001]	10 (7.4)[0.051]
	Other	19,663 (2.2)	30 (0.6) [<0.001]	3 (7.7)	1 (2.6)[0.439]	10 (7.4)[0.001]
Mode of delivery	SVD[3]	630,690 (75.2)[1]	3,639 (76.9)	17 (42.5)	2 (6.0)	29 (31.2)
	Planned caesarean	62,959 (7.5)	30 (0.6) [<0.001]	1 (2.5)	18 (54.6) [<0.001]	13 (14.0) [<0.001]
	Emergency caesarean	78,346 (9.3)	32 (0.7) [<0.001]	5 (12.5)[0.205]	10 (30.3) [<0.001]	13 (14.0) [<0.001]
	Vacuum	64,791 (7.7)	1,034 (21.8) [<0.001]	16 (40.0)[<0.001]	3 (9.1)[0.014]	38 (40.8) [<0.001]
	Forceps	2,474 (0.3)	37 (0.8)[<0.008]	1 (2.5)	0	0
Shoulder dystocia		2,060 (0.2)	204 (4.3) [<0.001]	1 (2.5)	2 (5.1)[0.007]	51 (35.4) [<0.001]
Child						
Sex	Female	437,132 (48.4)	1,935(40.9) [<0.001]	13 (32.5) [0.062]	15 (38.5)[0.281]	50 (34.7)[0.001]
	Male	466,697 (51.6)	2,800 (59.1)	27 (67.5)	24 (61.5)	94 (65.3)
Multiple Birth		26,638 (2.9)	26 (0.5) [<0.001]	2 (5)	7 (17.9) [<0.001]	6 (4.2)[0.703]
Preterm birth[4]	32-36	47,297 (5.2)	114 (2.4) [<0.001]	5 (12.5) [0.113]	4 (10.3)	16 (11.1)[0.008]

	<32	9,145 (1.0)	1 (0.02)	1 (2.5)	2 (5.1)	2 (1.4)
Birth weight (g)	<2,500	40,367 (4.5)	28 (0.6)$^{<0.001}$	3 (7.8)	6 (15.8)$^{0.063}$	7 (4.9)$^{0.127}$
	2,500-3,499	385,640 (42.8) [1]	770 (16.3)	10 (25.4)	20 (52.6)	31 (21.8)
	3,500-3,999	308,636 (34.2)	1,636 (34.6) $^{<0.001}$	16 (41) $^{0.121}$	7 (18.4)$^{0.077}$	36 (25.4)$^{0.161}$
	4,000-4,499	134,266 (14.9)	1,528 (32.3) $^{<0.001}$	7 (18) $^{0.246}$	3 (7.9)	32 (22.5) $^{<0.001}$
	4,500+	33,003 (3.7)	764 (16.2) $^{<0.001}$	3 (7.8)	2 (5.3)	36 (25.4) $^{<0.001}$
Head circumference (cm)	≤35	558,675 (63.8) [1]	2,090 (46.2)	18 (49)	22 (64.7)	60 (43,2)
	36-37	280,183 (32.0)	1,986 (43.8) $^{<0.001}$	16 (43) $^{0.674}$	10 (29.4) $^{0.961}$	45 (32,4) $^{0.054}$
	38+	36,445 (4.2)	451 (10) $^{<0.001}$	3 (8)	2 (5.9)	34 (24.4) $^{<0.001}$
SGA[5]	<2.5%	20,574 (2.0)	14 (0.3) $^{<0.001}$	0	2 (6.5)	2 (1.5)
	<10%	94,275 (10.4)	76 (1.6) $^{<0.001}$	3 (8)	10 (25.6)$^{0.011}$	9 (6.4)$^{0.119}$

[1]Reference category, [2]BMI: Body Mass Index, SVD: [3]Spontaneous Vaginal Delivery, [4]Preterm birth: <37+0 gestational weeks, [5]SGA: Small-for-gestational age

Table 5. Risk factors for birthrelated clavicle fracture (P13.4, ICD10 - N=4,673) in vaginally delivered infants born in Sweden 1997 to 2014. Crude and adjusted odds ratios (OR and aOR), and 95% confidence interval.

Exposure		**Clavicle fracture (only vaginal birth)**		
			Model 1[1]	Model 2[2]
		OR (95% CI)	aOR (95% CI)	aOR (95% CI)
Parity	I	1	1	1
	>I	1.54 (1.43-1.66)	1.10 (1.01-1.20)	1.11 (1.02-1.20)
Height	≥170	1	1	1
	160-169.9	1.22 (1.13-1.32)	1.50 (1.38-1.63)	1.47 (1.36-1.60)
	<160	1.32 (1.18-1.48)	2.11 (1.87-2.39)	2.02 (1.79-2.30)
BMI[3]	18.5-24.9	1	1	1
	25-29.9	1.53 (1.41-1.66)	1.27 (1.16-1.38)	1.26 (1.16-1.37)
	≥30	2.0 (1.81-2.20)	1.50 (1.36-1.66)	1.48 (1.34-1.65)
Dystocic labor		1.61 (1.44-1.79)	-	1.03 (0.89-1.19)
Shoulder dystocia		18.3 (15.1-22.3)	-	4.84 (3.70-6.32)
Delivery	SVD[4]	1	-	1
	Vacuum	2.24 (1.48-3.38)	-	2.52 (1.61-3.92)
Sex	Female	1	1	1
	Male	1.37 (1.18-1.46)		1.09 (1.01-1.80)
Birth weight (g)	2,500-3,499	1	1	1
	3,500-3,999	2.57 (2.32-2.85)	2.79 (2.50-3.13)	2.77 (2.48-3.10)
	4,000-4,499	5.53 (4.99-6.13)	6.09 (5.37-6.90)	5.91 (5.21-6.70)
	4,500+	13.3 (11.8-15.0)	14.7 (12.6-17.0)	13.2 (11.3-15.4)
Head circumference (cm)	≤35	1	1	1
	36-37	1.90 (1.77-2.04)	0.84 (0.77-0.92)	0.84 (0.77-0.92)
	≥38	3.80 (3.35-4.31)	0.91 (0.78-1.07)	0.92 (0.79-1.08)

[1]Model 1: Parity, maternal height and BMI, infant sex, birth weight, head circumference; [2]Model 2: Parity, maternal height and BMI, infant sex, birth weight, head circumference, prolonged labour, shoulder dystocia, mode of delivery, [3]BMI: Body Mass Index, [4]SVD: spontaneous vaginal delivery.